Direct Photon Measurements at PHENIX

Hard Probes 2012 – Flash Talk

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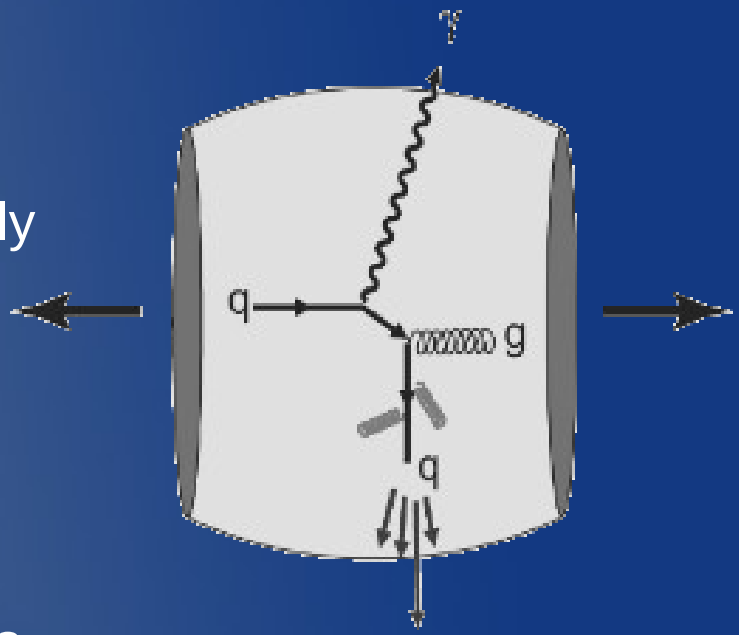
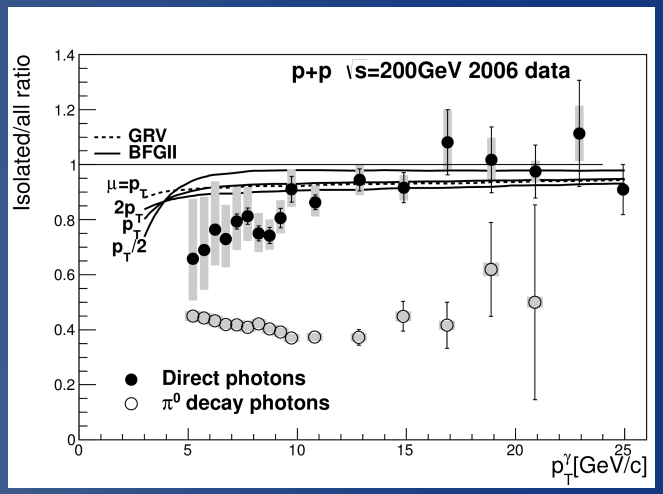
Why Measure Direct Photons?

- Au+Au (or Cu+Cu)
  - Do not interact strongly, traverse medium unaffected
  - Produced at every stage of the collision
    - High pT photons (mostly) from initial hard scattering, test of scaling behaviour w.r.t. p+p
    - Photons produced in medium probe QGP directly
- p+p
  - Test pQCD, direct access to initial 2->2 processes
  - Sensitive to gluon distribution in the proton (q+g → q+γ)
  - Important baseline for understanding other systems
- d+Au
  - Probe initial state, access to parton distribution functions
  - Important baseline for final state in Au+Au

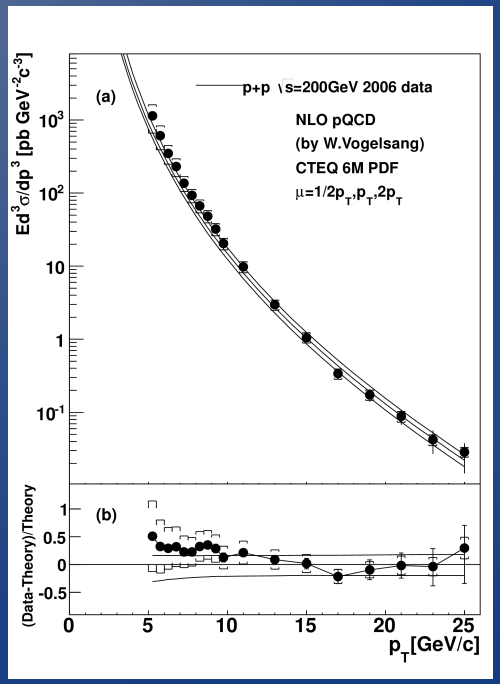


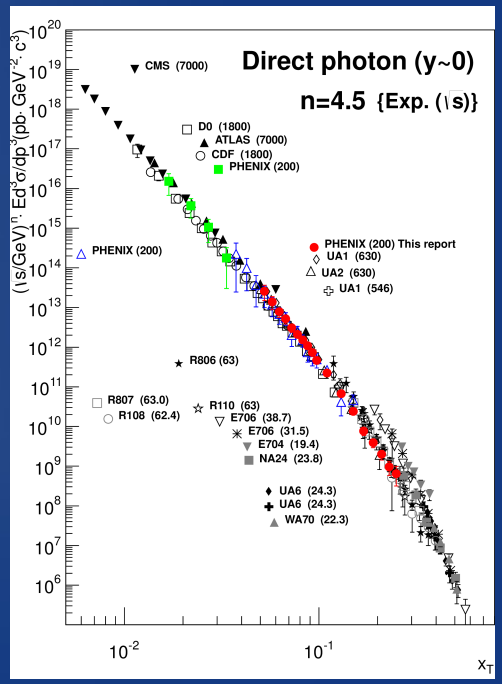
Results 1: direct photons in p+p

- Fraction of isolated photons is slightly rising at low p_T, flat at high p_T. It is consistent with pQCD calculation that predicts fraction of ~90%
- ~40% of π^0 decay photons pass isolation cut
- pQCD calculation is consistent with measured cross section
- x_T scaling behavior:
  - Scale cross sections from various p+p (p+pbar) with $\sqrt{s}^{4.5}$
  - All data on single universal curve, scaling consistent with NLO pQCD expectation



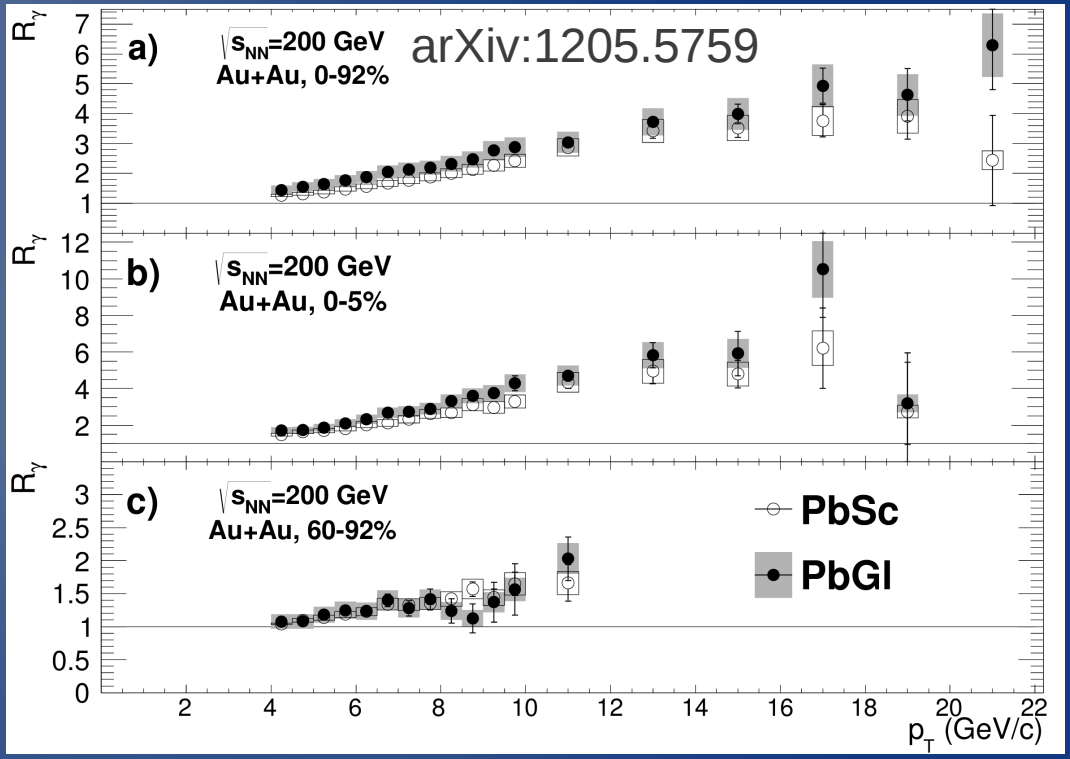
arXiv:1205.5533





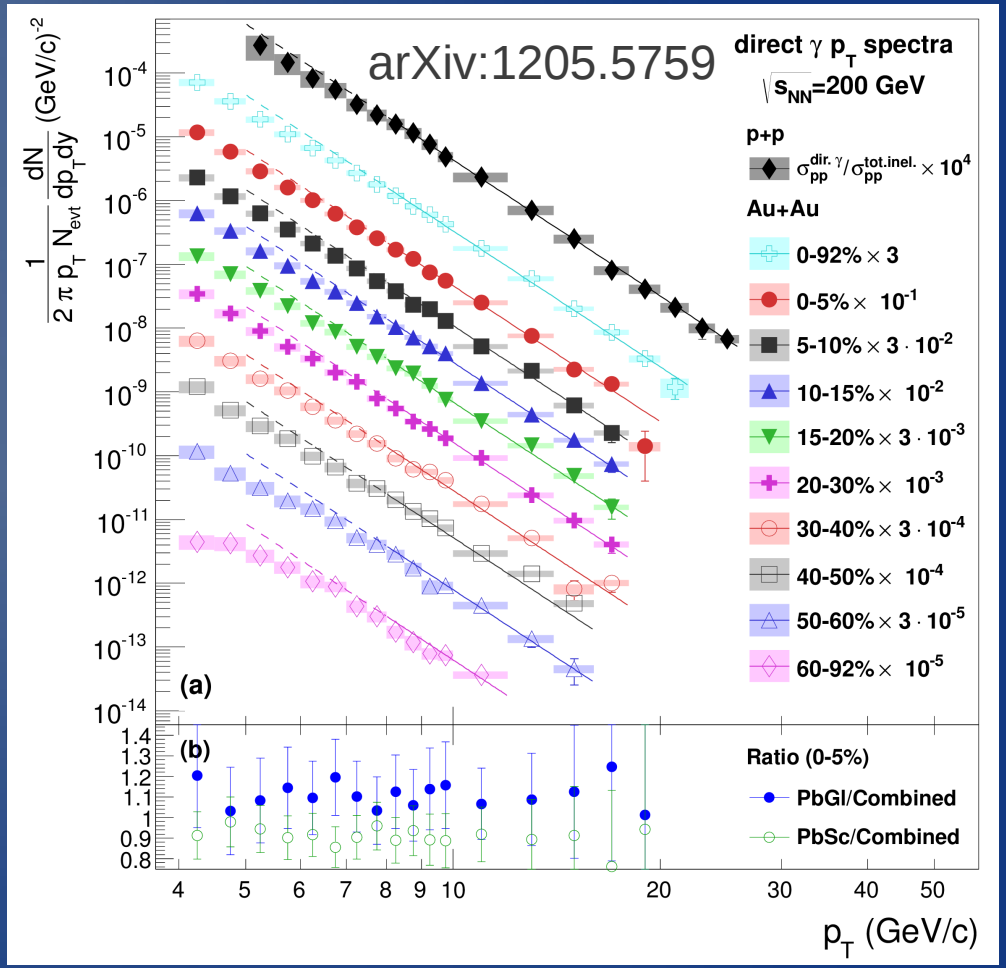
Results 2: Direct Photon Spectra

- Ratio $R_\gamma=(\gamma/\pi^0)_{data}/(\gamma/\pi^0)_{decayMC}$ shows direct photon signal as excess above 1



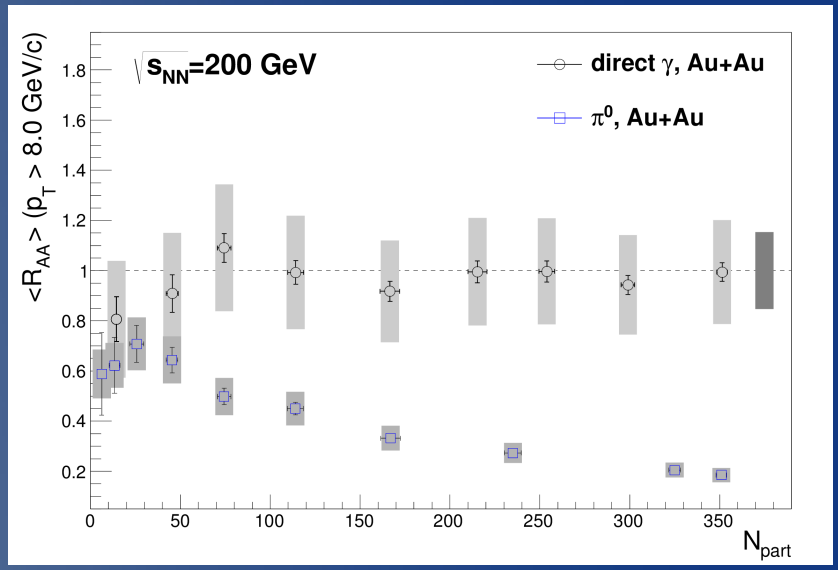
Results 2: Direct Photon Spectra

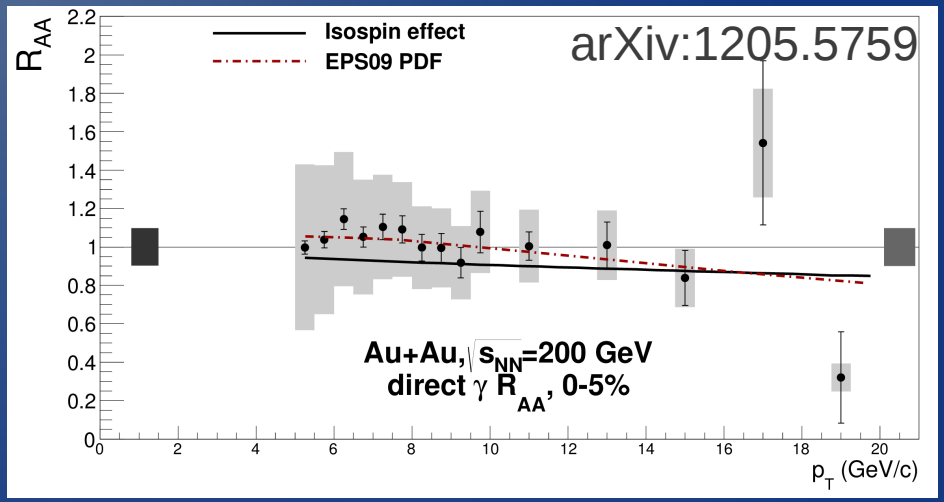
- Ratio $R_\gamma=(\gamma/\pi^0)_{data}/(\gamma/\pi^0)_{decayMC}$ shows direct photon signal as excess above 1
- Direct photons measured in p+p for 5 GeV/c<p_T<25 GeV/c, in Au+Au in 10 centralities for 4 GeV/c<p_T<22 GeV/c
- 2 independent analyses in Au+Au in good agreement
- Power law at high p_T, power for p+p is 7.08±0.09±0.1
- In Au+Au, power of 6.85±0.07±0.02, no apparent shape modification
- T_{AA} scaled fit to p+p shows that magnitude and shape in Au+Au agree with binary-scaled p+p



Results 3: R_{AA}

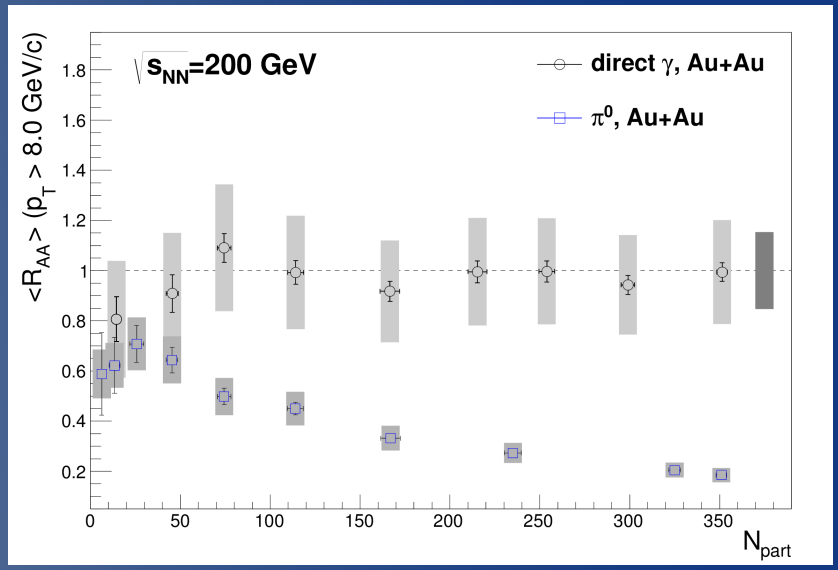
- R_{AA} is consistent with 1 for all centralities
- π^0 is suppressed towards higher N_{part}, direct photons are not
- Comparisons with models for initial and final state effects
  - Initial state effects (IS) include isospin and nuclear PDF, consistent with data

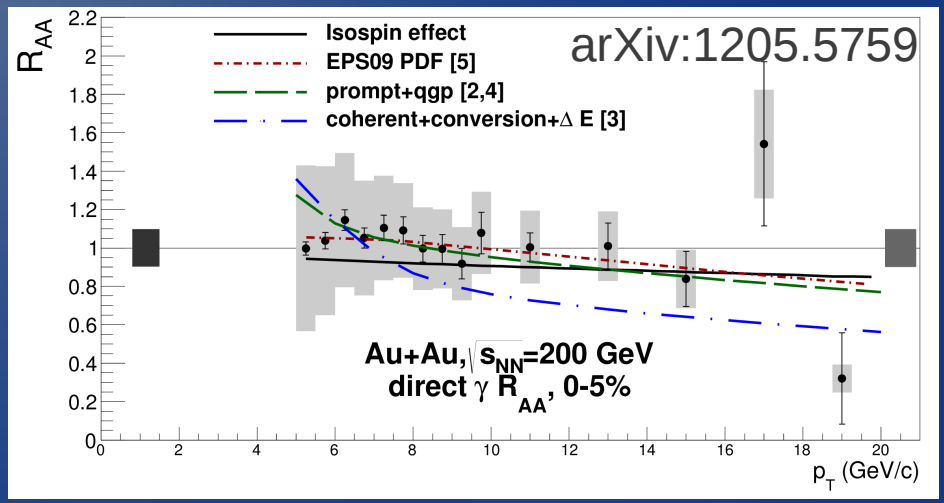




Results 3: R_{AA}

- R_{AA} is consistent with 1 for all centralities
- π^0 is suppressed towards higher N_{part}, direct photons are not
- Comparisons with models for initial and final state effects
  - Initial state effects (IS) include isospin and nuclear PDF, consistent with data
  - Final state effects (FS) include suppression of jet fragmentation photons and photons from jet-plasma interaction, consistent with data
  - Another model with both IS and FS disagrees with data





[2] PRC77, 024909
[3] PLB669, 337
[4] arXiv:0904.2184
[5] JHEP1104, 055

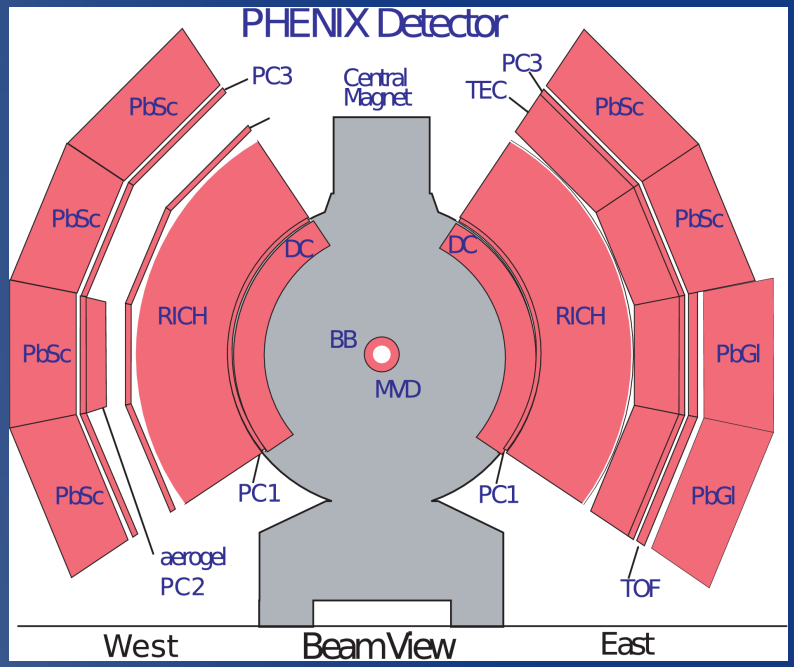
Summary and Outlook

- PHENIX has measured direct photons in p+p and Au+Au (amongst others)
- Observed power law behavior of cross section in both systems at high pT
- pQCD prediction agrees with p+p measurement, universal xT scaling behavior of photons was found
- In Au+Au, direct photons show no suppression or enhancement, RAA consistent with unity
- Theoretical models for IS agree with data, FS prediction including QGP effects also consistent with data (however,another model in disagreement)
- Future measurements: d+Au with 2008 data (study IS), lower energy Au+Au with 2010 data (clearer isospin effect picture?)

Thank You!

Method overview

- Used statistical methods
  - Measure all photons
    - Subtract hadrons/leptons from calorimeter spectrum
    - Correct for acceptance/efficiency
  - Simulate decay photons
    - Use measured π^0, m_T scale other mesons
  - Subtract decay photons via so-called double ratio $R_\gamma=(\gamma/\pi^0)_{data}/(\gamma/\pi^0)_{decayMC}$
  - Direct photon spectrum is $\gamma_{dir}=(1-1/R_\gamma)\gamma_{incl}$
- Variation of method
  - Simulate calorimeter answer to decay photons, subtract raw clusters, correct remaining direct photon sample for detector effects
- Further improvements in p+p
  - Tagging of π^0 decay photons
  - Isolation cut applied



- PHENIX detector
  - EMCal (PbGl, PbSc) for photon measurement
  - PC3 for charged particle rejection
  - BBC, ZDC for event characterization